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THE EFFECT OF VARIOUS STRATEGIES ON THE ACQUISITION, RETENTION, AND TRANSFER OF A SERIAL POSITIONING TASK

Robert N. Singer, Richard F. Gerson, and Susan Ridsdale
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PERSONNEL AND TRAINING RESEARCH LABORATORY



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July 1979

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by a transfer task involving 6 new criterion positions. Separate analyses for each of four dependent variables--absolute error (AE), constant error (CE), variable error (VE), and percent of correct responses--revealed "imagers" to be more accurate and less variable in their responses than the four other groups. However, control subjects displayed greater accuracy and less variability than either the kinesthetic, labeling, or informed-choice groups. Such results suggest the importance of implementing strategies that are compatible with individual cognitive styles.

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FOREWORD

The Personnel and Training Research Laboratory of the Army Research Institute for the Behavioral and Social Sciences (ARI) conducts research to support training methods to optimize skill acquisition and retention. A variety of research is being conducted on the effects of various learning strategies on skill acquisition and retention. ARI, in cooperation with the Defense Advanced Research Projects Agency (DARPA), is especially interested in training strategies for acquisition, retention, and transfer of motor skills. This report discusses the effectiveness of learning and retention under five different learning strategies and the implications of the findings for motor skill development. Research was conducted at Florida State University under contract MDA903-77-C-0020, which was monitored by Joseph S. Ward of ARI under Army Project 2Q161102B74F and funded by DARPA.

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THE EFFECT OF VARIOUS STRATEGIES ON THE ACQUISITION, RETENTION,
AND TRANSFER OF A SERIAL POSITIONING TASK

BRIEF

Requirement:

To analyze the effectiveness of various learner strategies upon initial learning, retention, and subsequent transfer of a motor skill.

Procedure:

Fifty college students were randomly assigned to one of five strategy conditions: imagery, kinesthetic, labeling, informed-choice, and control. The task, using a curvilinear repositioning apparatus, required participants to replicate six limb movements to predetermined criterion locations. Following the learning trials, participants were given a retention test, followed by a transfer task involving 6 new criterion positions.

Findings:

Separate analyses for each of four dependent variables (absolute error, constant error, variable error, and percent of correct responses) revealed "imagers" to be more accurate and less variable in their responses than the four other groups. However, control subjects displayed greater accuracy and less variability than either the kinesthetic, labeling, or informed-choice groups.

Utilization of Findings:

Results suggest the importance of implementing strategies that are compatible with individual cognitive styles.

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THE EFFECT OF VARIOUS STRATEGIES ON THE ACQUISITION, RETENTION, AND TRANSFER OF A SERIAL POSITIONING TASK.

INTRODUCTION

In recent years, researchers have shown an increased interest in the cognitive processes which may primarily influence the learning of various matter. This thrust, in turn, has generated numerous approaches to examine the effectiveness of a number of learner strategies to facilitate the acquisition and retention of verbal material. To a much lesser degree, the use of strategies within the motor learning domain has been of concern.

An effective learning strategy has been defined as the simplest and most efficient means of processing the information inherent in a situation (Newell & Simon, 1972). Rigney (1978) suggested that a strategy may be interpreted as signifying operations and procedures a learner may adopt to acquire, retain, and to retrieve different kinds of information. Similarly, Bruner, Goodnow, and Austin (1956) have written that a strategy provides the learner with a pattern of decisions for the acquisition, retention and future utilization of information. Based upon an interpretation of the preceding definitions, it would appear that a strategy, or combinational strategies, developed by the learner in accordance with his/her cognitive abilities and situational demands, are effective in relating new information to previously obtained knowledge (Bruner, 1961).

Within the area of verbal learning, the use of

learner strategies has facilitated the acquisition and retention of specific information across a variety of age groups (Belmont & Butterfield, 1971; Bruner, Goodnow, & Austin, 1956; Hagen, Hargrove, & Ross, 1973; Kingsley & Hagen, 1975). Various strategies such as mnemonics, encoding, rehearsal, and labeling have proven to be effective in the acquisition and retention of information for immediate recall. Typically, experiments involve the presentation of letter lists which must be committed to memory in order to be recalled immediately following presentation. The effectiveness of particular strategies is usually assessed by the length of interim pauses during list learning (Belmont & Butterfield, 1971) and correctness of response during serial recall (Maccoby & Hagen, 1965).

In order to ascertain the effectiveness of naming or labeling stimuli during acquisition on later recall, Atkinson, Hansen, & Bernbach (1964) devised a serial recall task. Picture cards were arranged in a horizontal line and displayed one at a time to the subject. After presentation, each card was returned face down. Once four to eight cards had been shown, a cue card was presented and the subject's task was to point to the card in the series that matched the cue card. Results indicated the subjects who used a labeling strategy were able

to recall a higher percentage of pictures correctly than control subjects. Additionally, the serial order recall was better for strategy groups than for non-strategy groups. Hagan and Kingsley (1968) developed a similar paradigm in which children 4, 6, 7, 8, and 10 years of age were tested in conditions where verbal naming was either required or not required. Results indicated that with middle-age group children, labeling facilitated learning while at the youngest and oldest levels, no change in recall occurred.

Researchers have demonstrated that concrete stimuli (i.e., pictures and designs) are more easily retained than abstract verbal material (Bevan & Steger, 1971; Paivio, 1969) and that imagery appears to be a more effective mnemonic than verbal labeling in paired associate tasks using concrete noun pairs (Paivio & Foth, 1970). Similarly, when learners are instructed to imagine a mental picture formed by specific word-pairs or to use a visual image (Bower & Winzenz, 1970; Paivio & Yuille, 1969) learning is enhanced.

Although particular strategies may be more adaptable to specific tasks, the general conclusions in studies designed to determine the effectiveness of learner strategies are unequivocal. The application of appropriate mental operations which are compatible with a learner's

cognitive capabilities leads to superior performance attainment as compared to individuals who do not utilize the same strategy operations.

Learning strategies can also facilitate the storage as well as retrieval of verbal information. Several types of strategies that have been shown to promote learning are the learner's free choice of mnemonic techniques, various encoding instructions, or instructions in the use of particular strategies (Craik & Lockhart, 1972; Craik & Tulving, 1975). Although the dependent measures differ, the conclusions drawn remain similar. Strategy usage has a facilitatory effect on the acquisition and retention of information.

The implication for motor learning would appear to be that the use of strategies should facilitate the learning process. However, while there exists an abundance of supportive evidence for strategy usage within the verbal learning area, research is severely lacking within the motor learning domain. Thus, inferences must be drawn from verbal learning research as to the potential beneficial effects of various types of strategies on the acquisition and retention of motor skills.

In an attempt to apply verbal labeling strategies to a motor task, Shea (1977) required subjects to reproduce a single criterion position on a manual lever

positioning apparatus after experiencing the movement once. Of the three groups tested, one group was provided with relevant labels, one group created its own irrelevant labels, and one group had no labels. The relevant label group showed significantly higher recall scores than either of the other two groups. Additionally, no decrement in recall was observed over time (60 sec) when relevant labels were provided. Such results lend credence to the notion that a meaningful labeling strategy enhances the storage of information as well as facilitating later recall.

Similarly, Housner and Hoffman (1979) investigated the role of imagery in the reproduction of criterion points and locations. Subjects were instructed to formulate a mental picture of their hands moving to the criterion position or at the end location point. During rest intervals, some subjects were required to employ imaginal rehearsal while others were prohibited from rehearsing by the use of distractor tasks. Results indicated that those subjects who applied the imagery strategy during the movement to end locations and also during rest intervals displayed superior recall of the criterion points. Similar results were reported by Hagenbeck (1978), who investigated the effectiveness of imagery, irrelevant labeling, relevant labeling, and

kinesthetic awareness on the learning of six serial positions in a curvilinear repositioning task. However, Hagenbeck required imagery subjects to mentally picture the criterion positions as analogous to the numbers of a clock face. Of the three strategy groups, imagery was found to be most effective during reproductive movements.

Ridsdale (1978) compared chunking, overt rehearsal, forced choice, and free choice strategies and their influence on subjects attempting to learn a card sorting task. The chunking strategy was shown to be more effective for skill acquisition while free-choice (self-generated) strategies yielded better performances in retention. It would appear from data such as these that particular strategies may be appropriate with particular types of people, e.g., a strategy X cognitive style arrangement. Whether or not such a notion is tenable remains open to speculation. However, the results of preliminary investigations on the effectiveness of strategies within the motor learning domain closely parallel verbal learning findings in that individuals who are guided in their use of strategies show superior performance in relation to control groups.

Although tasks of location reproduction and card sorting require both cognitive and motor capabilities, the demands of everyday life often require individuals to

perform motor skills of far greater complexity than these tasks. Additionally, they might have to transfer knowledges and skills to new learning situations. However, while the use of cognitive strategies has been shown to facilitate the acquisition and retention of newly learned material (e.g., Campione & Brown, 1974; Kendler, 1964; Kendler & Kendler, 1962), the generalizability (transfer) of these same strategies to different situational contexts is questionable.

Still, there are those (Gagné, 1977; Singer & Gerson, in press; Wichelgren, 1974; Wittrock, 1967) who contend that rather than being oriented to specific kinds of external content, such as language or numbers, cognitive strategies are and should be, largely independent of content and apply to all types of learning conditions.

As Gagné' (1977) has pointed out, the difficulty lies in arranging conditions so that transfer can be demonstrated. Strategy transfer usually cannot occur unless the initial learning environment includes some reference to the transfer situation (Bransford, Franks, Morris, & Stein, 1978; Campione & Brown, 1974), such as the temporal structuring of the components within each task being similar (Keele & Summers, 1976). Campione and Brown (1974) suggested that transfer is best when the form of the two situations remains the same. More specifically,

context may well direct one's attention toward relevant facts. A familiar problem in a new context fails to elicit any strategy since nothing in the situation cues the learner how to approach the problem. Investigations dealing with elementary children (Campione, 1973) have provided additional evidence for the context-tied problem. To overcome this circumstance, Campione (1973) suggested that when individuals learn useful problem-solving strategies, these strategies should be employed in a variety of situations so that a particular strategy is not restricted to a specific context. It would appear, then, that strategies which enhance skill acquisition and retention also have the potential to transfer to the learning of a skill in a new situation with similar parameters.

As was previously suggested, the lack of research concerning strategy effectiveness within the motor learning area has necessitated a heavy reliance upon the findings reported in the verbal learning literature. In many of these investigations, serial recall tasks have been used, where subjects are given words successively and are then required to report them in the same order presented. Such tasks are representative of the serial events in everyday life that require an individual to learn what item follows or is adjacent to another in a spatial or temporal array.

However, while the serial recall tasks developed by

verbal learning theorists require individuals to recall and then verbally repeat, serial motor tasks would appear to involve both cognitive and motoric response processes. For example, consider the novice learning to execute a routine on the uneven parallel bars or an individual attempting to recall and reproduce a card-sorting sequence. The task demands in these two situations require the mastery of a sequential set of events. A serial set of responses needs to be performed correctly, temporally and spatially, in order for the entire activity to be judged as acceptable.

A common feature in experiments of serial learning of cognitive tasks is for the subject to learn word lists of nonsense syllables. Based upon subject responses, researchers are able to analyze the serial position curve (primacy-recency effects) in an effort to determine how an individual imposes strategies or which particular strategies may be most efficient in prompting recall accuracy. A motor task, the curvilinear positioning apparatus, which involves serial recall, has been compared to the task of learning word lists (Magill, 1976). In Magill's experiment, a series of criterion positions were established and the subject was required to reproduce them in order. Results were analyzed in a manner paralleling the serial learning of word lists. However, Magill's data did not reflect the

typical U-shaped curve associated with the primacy-recency effect. Rather, analysis indicated that subjects learned the three criterion positions in order of presentation (i.e., position 1 was learned best, then position 2, and finally position 3).

Previous research (Harcum, 1975) indicated that in serial learning the subject makes fewer errors for items that are favored by the internal structure of the series. This organizational structure may be developed by the attitude, past experience, and cognitive style of the learner. A premise in serial learning in terms of acquisition strategies is that the subject first learns the initial item and then begins to make associations based upon that item (Harcum, 1975). Several investigations within the cognitive field (Spielberger & Smith, 1966; Underwood & Keppel, 1963) showed that acquisition strategies can be manipulated by the experimenter, thus influencing perception about the first item and subsequent associations.

The perception of the first item in a series is a critical feature in the storage of items. Its importance lies in the significance of the temporal and spatial ordering in serial learning. As was suggested previously, this ordering may be simple or complex, based upon the task difficulty. With the curvilinear positioning apparatus,

the spatial array of the criterion locations and the speed with which the subject moves the lever to each point during acquisition may affect recall accuracy. In the serial recall of verbal items, Aaronson (1968) showed that more errors were committed for middle items when faster rates of presentation were used during acquisition. This bowing effect of the serial positioning curve has been attributed in the verbal learning literature to interference that may emanate from sources such as competition of responses, lack of discrimination, or ambiguity concerning the best order of acquisition (Harcum, 1975). Atkinson and Shiffrin (1968) have argued that if the interference is due to cognitive processes under the control of the subject, such as memory search, then corrective measures can be taken.

The ability of the learner to make corrections to reduce interference suggests the importance of a cognitive strategy. In line with this notion, Harcum (1975) has suggested that organizational strategies can eliminate or effectively reduce interference since the construction of different codes reduces the number of possible alternative responses.

Both imagery and labeling strategies have been shown to enhance the learning of a repositioning task (Hagenbeck, 1978; Housner & Hoffman, 1979). However, since the task

additionally requires movement to a specific location, kinesthetic information concerning the feel of that movement may be of value to the learner (Schmidt, 1975).

Therefore, it was the purpose in the present study to analyze the effectiveness of various strategies on acquisition, delayed retention, and subsequent transfer with a repositioning task. The following strategy conditions were investigated: imagery, labeling, kinesthetic, and informed choice.

In line with the consistent finding that strategy usage enhances initial learning, it was hypothesized that: subjects applying a particular strategy would display superior performance across all three conditions (acquisition, retention, and transfer) when compared to control subjects who used no designated strategy. Previous research (Hagenbeck, 1978; Housner & Hoffman, 1979) with repositioning tasks has indicated superior learning for imagery strategy groups. Therefore, it was hypothesized that during acquisition and retention trials, subjects in the imagery group would perform better than either the kinesthetic or labeling groups.

Although the potential for the transfer of strategies from one task to another is evident, relatively few investigations have dealt specifically with this area. However, it would appear that strategies that are compatible

with the learner's cognitive style (Pask, 1975; Ridsdale, 1978) may be more amenable to transfer situations. More specifically, imposed strategies may enhance initial learning and retention, however, transfer requires an individual to identify the existent similarities between tasks. Thus, a self-imposed strategy consistent with the learner's cognitive style, may be more easily applied in transfer situations. Therefore, it was hypothesized that subjects in the informed choice group would display a greater degree of transfer learning between the acquisition and transfer task.

METHODS

Subjects

Male and female undergraduate and graduate students (M age = 21.42 yrs; SD = 2.34) from Florida State University volunteered to participate in this study.

Apparatus

The task involved the replication of limb movements on a curvilinear repositioning device. The apparatus consisted of a metal pointer, 25 cm long, attached to a flat metal base, 36 cm X 64 cm. The pointer rotated on a ball bearing mechanism, such that the pointer could be moved through a range of 200° in the horizontal plane. To facilitate a subject's movement of the pointer, a

pillarlike handle, 8.25 cm high, was attached vertically to the pointer 14 cm from the axis of rotation. On top of the base, lines and numerals were engraved so that degrees of rotation were represented in one and five unit increments. Finally, a portable black screen with a black cloth draped over the frame was mounted to the base and was positioned on the subject's side of the display to prevent viewing of the pointer and the degree markings during movement. Auditory feedback was controlled by the near-frictionless movement of the pointer.

Procedure

Subjects entered the test area and a strategy condition (which will be described shortly) was randomly assigned to each subject. The subject was then seated in a chair facing the apparatus, which was situated on a table of normal height. Each subject was aligned with the apparatus so that the right shoulder was directly behind the start point (0°). To ensure consistency of movement, the subject's elbow was secured on a 21 X 20 X 2.3 cm square rest pad such that elbow placement was halfway between the start point and the shoulder joint. The subjects were informed to grasp the handle with their fingertips to maximize movement solely about the wrist joint. Immediately following this procedure, each subject was blindfolded.

Subjects were instructed in the use of the particular strategy assigned to them as they entered the test area. There were five strategy conditions: (1) imagery, where subjects were instructed to mentally picture that each criterion position represented a numeral which appeared in the top half of a clock face; (2) labeling, where subjects were told the exact number of degrees they moved from the start position to each criterion point; (3) kinesthetic awareness, a strategy unique to limb positioning tasks, which required subjects to concentrate on the feel of their limb as it moved from the start position to the criterion position; (4) informed choice, where subjects were instructed in the use of the three previously mentioned strategies and were then asked to select any one or combination of strategies they thought would be most effective; and (5) control, where subjects received no instructions as to strategy usage but were also not restrained from self-generating a strategy.

Following instructions in strategy usage, subjects in each group performed two practice trials. Six criterion positions were randomly selected for this phase of the experiment with the restriction that there be only two target points in each of the short (0° - 60°), medium (61° - 120°) and long (121° - 180°) response sectors: 95° , 80° , 25° , 125° , 45° , and 150° . The subject's task

during the familiarization portion of the study was to move to each criterion position denoted by a stop peg. On each trial, the subject was told to grasp the handle and to move it lightly until a stop peg was encountered. No restrictions were placed on the speed of the movement, but subjects were told to move slowly and continuously.

After a 2 sec contact with the peg, the subject was told to release the handle and the experimenter returned it to the start position. The subject was then told to regrasp the handle and to move to the second stop peg (the first one having been removed by the experimenter). This stop peg constituted the second criterion position, and after a 2 sec delay at this position, the subject released the handle and once again, the experimenter returned it to the start position. This sequence of commands and associated movements was followed for all six criterion positions for each of the two practice trials.

Following the two practice trials, subjects in each group replicated the six criterion positions on 8 acquisition trials without the stop pegs. Knowledge of results in the form of direction and extent error information was provided by the experimenter relative to each position after every trial. In order to ensure that each subject had sufficient time to implement the

KR within his/her strategy, a 10 sec inter-trial post-KR period was administered. On all evenly numbered trials (with the exception of trial 8) subjects were cued (reminded) to continue to use their specific strategy. Upon completion of the eighth strategy acquisition trial, all groups were subdivided into two smaller groups for the retention phase of the study.

Subgroup 1 of each strategy condition received a one trial recall test on all six criterion points after a 20 sec unfilled retention interval. During this interval, the subject merely rested while waiting to again replicate the criterion positions. Subgroup 2 subjects were required to complete written addition problems during a 20 sec filled retention interval prior to the recall test. The task occupied certain cognitive and motoric capacities of each subject. Following the retention test there was a 2 min rest period before the transfer task. During the rest period, a questionnaire concerning the use of strategies was administered to each subject.

For the transfer task, six new criterion positions were randomly chosen under the same previous restrictions: 100° , 70° , 40° , 175° , 35° , and 130° . All procedures for this phase of the study were identical to those employed in the acquisition portion with the exception that only

one practice trial with pegs was given and no mention was made of strategy usage nor were strategy cues given. Additionally, subjects were not required to perform a retention test, although they did respond to the same questionnaire administered following the retention test. All questions corresponded to performance on the transfer phase of the task.

RESULTS

Factorial analyses of variance were individually conducted on each of the four dependent variables: absolute error (AE), constant error (CE), variable error (VE), and percentage of correct responses at a particular position. Newman-Keuls range tests were used as follow-up tests on all significant main effects, and tests of simple main effects were performed on all significant interactions. The results of these analyses will be reported separately.

Absolute Error

A 5 X 6 X 2 X 8 (strategies X positions X acquisition/transfer tests X trials) factorial ANOVA with repeated measures on the last three factors, yielded four significant main effects and a two-way and a three-way interaction. The strategy condition was significant, $F(4, 5) = 4.00$, $p < .01$, and the follow-up test revealed

that the kinesthetic group was less accurate than either the imagery, labeling, or control groups; the informed choice group showed greater error than the imagery, labeling, and the control groups; the labeling group was less accurate than the imagery and the control groups; and the control group was less accurate than the imagery group. Mean scores for each of these conditions and all subsequent significant effects are provided in Table 1.

The position main effect was significant, $F(5, 45) = 6.24$, $p < .01$, and the follow-up test indicated that positions 4 and 5, although not different from each other, were associated with more error than the other four positions. Additionally, accuracy at position 1 was greater than positions 2 and 3, at which greater accuracy was shown than at position 6.

The test main effect was significant, $F(1, 45) = 4.94$, $p < .01$, with performance on the transfer test being more accurate than reproduction on the acquisition test. Finally, the trials main effect was significant, $F(7, 315) = 19.94$, $p < .01$, with the greatest accuracy being evidenced on trial 8 when compared with trials 1 through 4. Additionally, performance on trial 2 was less accurate than on trials 4 through 7, performance on trial 3 was less accurate than trials 5 through 7, and performance on trial 4 was less accurate than trials 5 and 7.

Table 1
Mean Scores of Significant Effects for AE (in degrees)

Strategy	Imagery	Labeling	Kinesthetic	Inf. Choice	Control
Position	6.14	9.40	11.25	10.90	8.01
Test	1	2	3	5	6
Acquisition				Transfer	
Trials					
1	2	3	4	5	6
12.46	10.71	9.83	8.92	7.83	8.37
1	2	3	4	5	6
Position					
Strategy					
Imagery	4.11	5.64	5.32	6.48	7.02
Labeling	7.04	9.27	7.46	11.57	10.68
Kinesthetic	8.04	9.44	11.19	17.72	11.79
Inf. Choice	8.98	9.62	8.94	10.71	14.77
Control	7.74	8.53	9.01	6.89	8.69

The significant strategies X positions interaction, $F(20, 225) = 2.31, p < .01$, is illustrated in Figure 1. Tests of the simple main effects yielded the following differences among the means. At position 1, the kinesthetic and informed choice groups were less accurate than the other three groups, but they were no different from each other. At position 2, the imagery group was more accurate than the other four groups, which were not different from each other. All groups were different at position 3 except the informed choice and the control. At position 4, only the labeling and the informed choice groups evidenced similar accuracy. At position 5, differences existed among all groups except the labeling and the kinesthetic groups. Finally, at position 6, the informed choice group was less accurate than all the others, the labeling group had greater error than the imagery or the control groups, and the kinesthetic group was less accurate than the control group. There was a significant position X test X trials X interaction, $F(35, 315) = 1.70, p < .05$. These means are also reported in Table 1.

A secondary analysis was conducted on the AE scores to determine if there were effects of interfering activity during the retention interval, and if performance on the one-trial retention test differed from performance on the last trial of the acquisition test. Neither of these

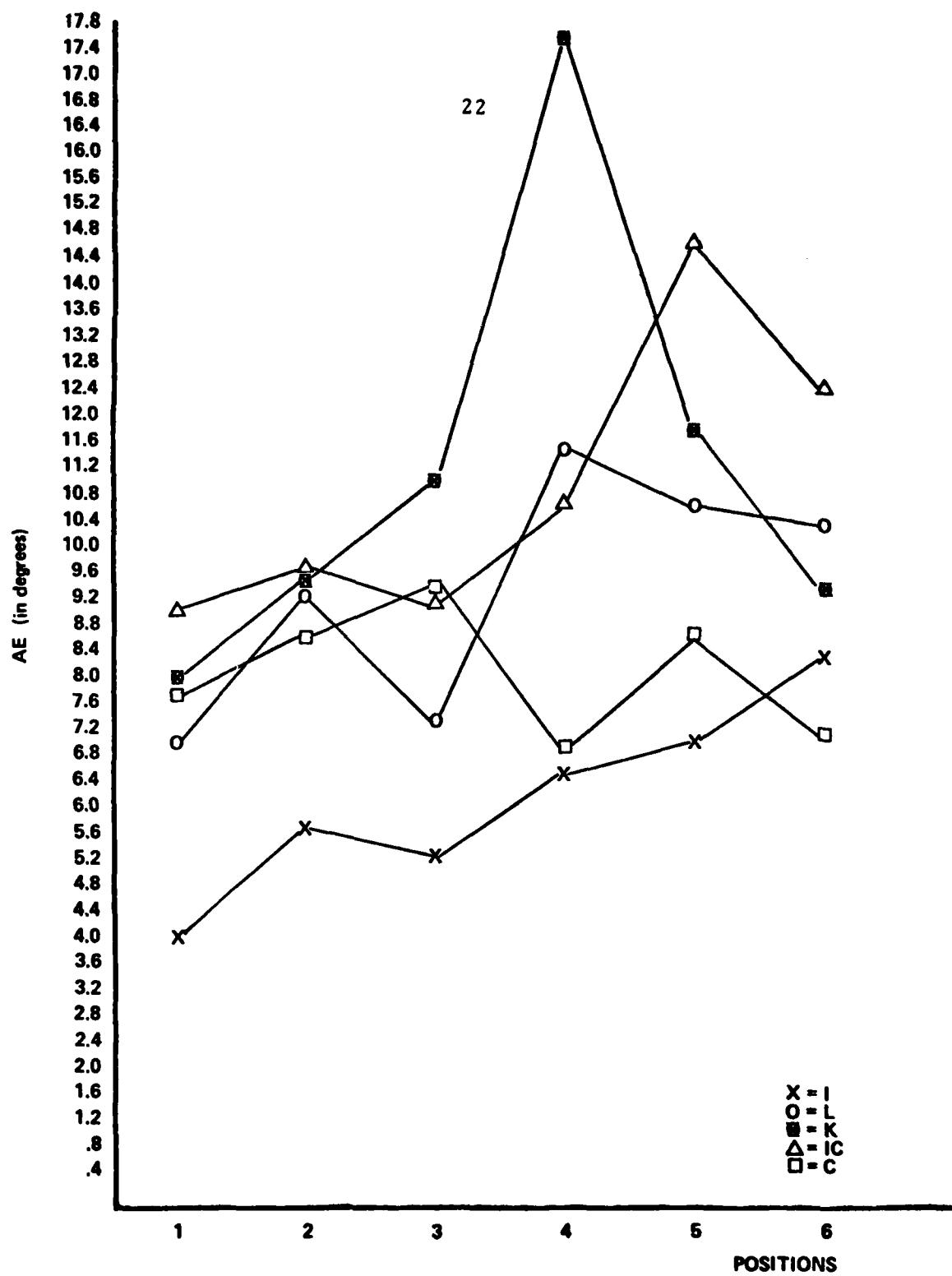


Figure 1. Strategy X position interaction for AE.

results was significant. The other results of the analysis of retention were identical to those reported for acquisition-transfer, so they will not be mentioned.

Variable Error

A 5 X 6 X 2 (strategies X positions X tests) factorial ANOVA with repeated measures on the last two factors, yielded significant main effects for strategies, $F(4, 45) = 5.06$, $p < .01$, and for positions, $F(5, 225) = 9.96$, $p < .01$. The follow-up test on the strategies effect showed that the informed choice group was more variable in their performance than all the other groups. In fact, all the groups showed differences in response consistency, with the imagery group being the least variable, followed by the control, labeling, and kinesthetic groups. The follow-up on the position means revealed greater variability at positions 4, 5, and 6, than at positions 1, 2, and 3, with no differences occurring within the subgroups of three positions. These means are reported in Table 2.

There was also a significant strategies X positions interaction, $F(20, 225) = 2.17$, $p < .01$. The means are also given in Table 2, and an illustration of this interaction is provided in Figure 2. Tests of the simple main effects yielded the following differences among strategy groups at each position. No differences were

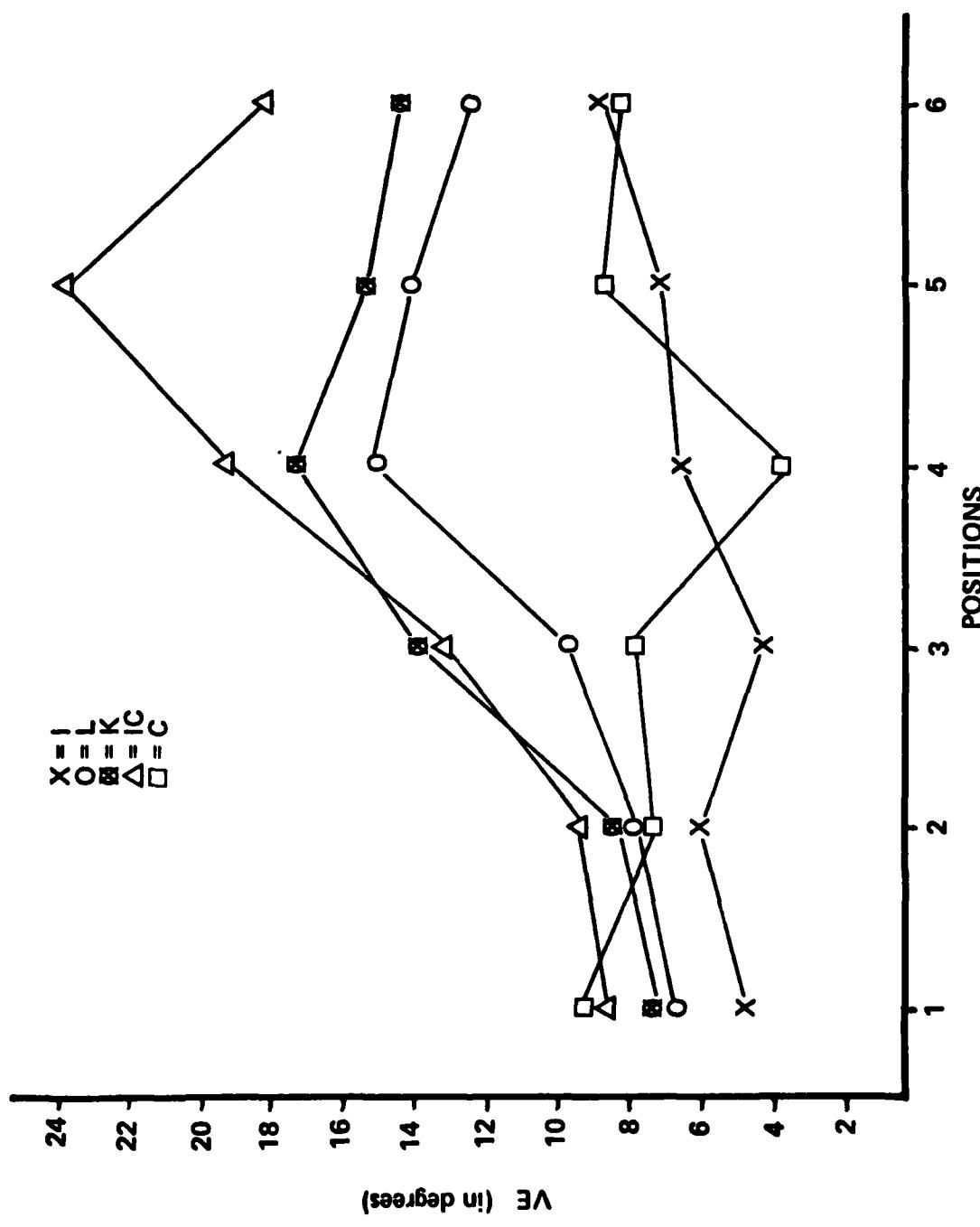


Figure 2. Strategy X position interaction for VE.

Table 2
Mean Scores of Significant Effects for VE (in degrees)

Strategy	Imagery	Labeling	Kinesthetic	Inf. Choice	Control
Position	6.19	10.98	12.59	15.39	7.63
	1	2	3	4	6
Position	7.34	7.75	9.72	12.50	13.68
	1	2	3	4	5
<hr/>					
Strategy	4.75	6.00	4.38	6.50	7.03
Imagery	6.78	7.85	9.72	15.11	14.04
Labeling	7.16	8.15	13.46	17.21	15.22
Kinesthetic	8.91	9.27	13.27	19.17	23.71
Inf. Choice	9.09	7.48	7.79	4.99	8.42
Control					8.04

found at positions 1, 2, and 6, while at position 3, both the kinesthetic and informed choice groups, although not different from each other, were more variable than the imagery group. At position 4, the labeling, kinesthetic, and informed choice groups were not different, but they all evidenced less response consistency than the imagery and the control groups. Finally, at position 5, the informed choice group demonstrated greater variability than the other groups, and the labeling and kinesthetic groups were less consistent than the imagery and the control groups. It is apparent that the VE results are highly similar to the results of the AE analysis, which is indicative that the problems in response accuracy are greatly affected by inconsistency in response production.

Constant Error

A 5 X 6 X 2 X 8 (strategies X positions X tests X trials) factorial ANOVA with repeated measures on the last three factors yielded only a significant positions main effect, $F(5, 45) = 4.12$, $p < .01$, and three significant two-way interactions. For the positions effect, it was found that short movements were overshot, and long movements were undershot, which is the typical range effect. Mean scores for this effect and the significant interactions that follow are given in Table 3. The bias

Table 3
Mean Scores of Significant Effects for VE (in degrees)

Position	1	2	3	4	5	6
Position	.45	.35	4.62	-3.62	.14	-.87
Strategy	1	2	3	4	5	6
Imagery	.02	.08	2.22	-2.48	2.91	1.95
Labeling	2.04	-5.11	4.56	-9.30	2.56	.75
Kinesthetic	-.80	-2.93	12.38	-13.31	3.97	-.92
Inf. Choice	-.16	-.97	2.38	5.01	-7.64	-3.40
Control	1.13	10.65	1.54	1.96	-1.11	-2.73
Position	1	2	3	4	5	6
Test						
Acquisition	.44	2.24	8.01	-.62	-.94	-4.41
Transfer	.45	-1.55	1.17	-6.63	1.21	2.67
Trials	1	2	3	4	5	7
Position	1	2	3	4	5	6
1	.77	-.10	-.07	.19	.67	.78
2	-.44	-1.94	-1.50	-.69	-.58	10.19
3	7.73	6.94	5.99	3.56	2.24	3.26
4	-8.30	-6.85	-2.81	-1.95	-2.19	-2.07
5	9.30	2.40	-3.01	-5.17	.11	-.18
6	-2.49	-2.25	-1.23	.12	.34	-.47

in responding that is most evidenced by the positive errors made at position 3, and the negative errors made at position 4 is made even more obvious by the strategies X positions interaction, $F(20, 225) = 3.18, p < .01$. The interaction is shown in Figure 3, and the response biasing at positions 3 and 4 is further supported by the relatively large VE's at these positions in Figure 2.

There was a significant positions X test interaction, $F(5, 225) = 5.46, p < .01$, and this is shown in Figure 4. Upon inspection of the figure, it can be seen that the problems in responding to movements in the middle of a sequence are consistent across both the acquisition and transfer tasks, although a similar trend in performance is evidenced with both tasks at these positions.

Finally, there was a significant positions X trials interaction, $F(35, 1575) = 1.63, p < .05$, which is shown in Figure 5.

A secondary analysis was conducted on the CE scores to determine if there were effects of interpolated activity during the retention interval, and if performance on the one-trial retention test differed from performance on the last acquisition trial. Neither of these effects was significant.

Percentage of Correct Responses

The fourth dependent variable that was analyzed was

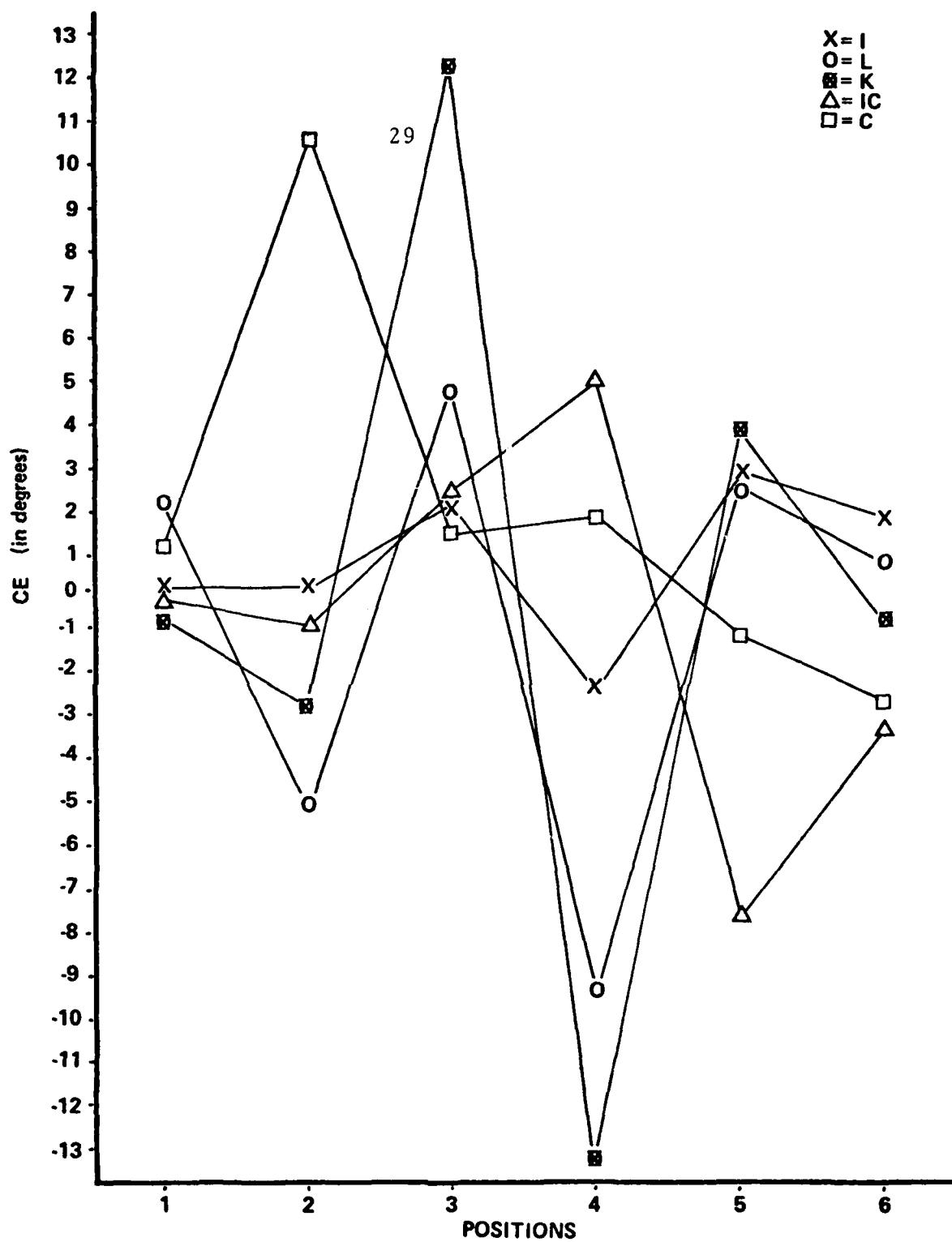


Figure 3. Strategy X position interaction for CE.

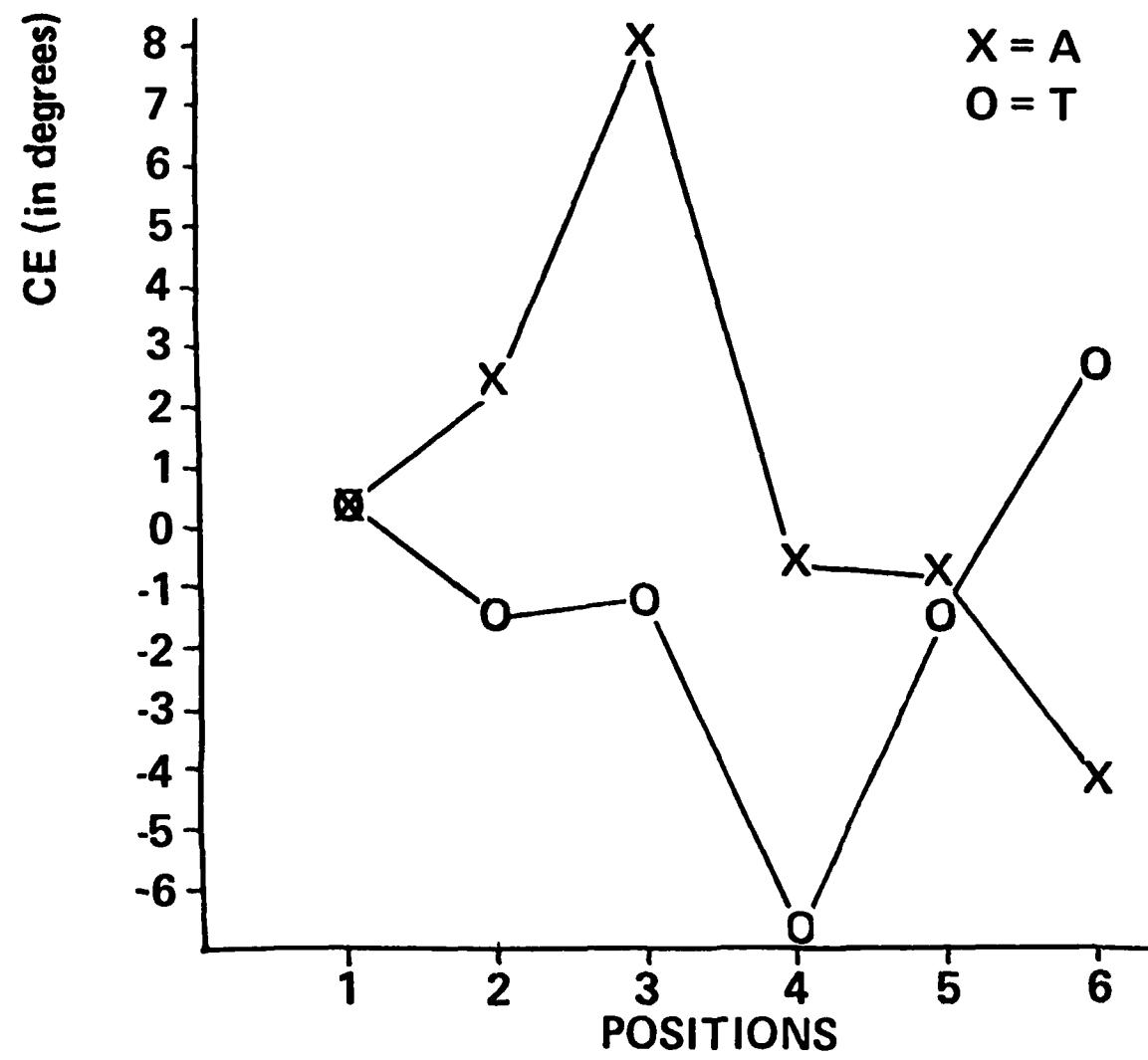


Figure 4. Positions X test interaction for CE.

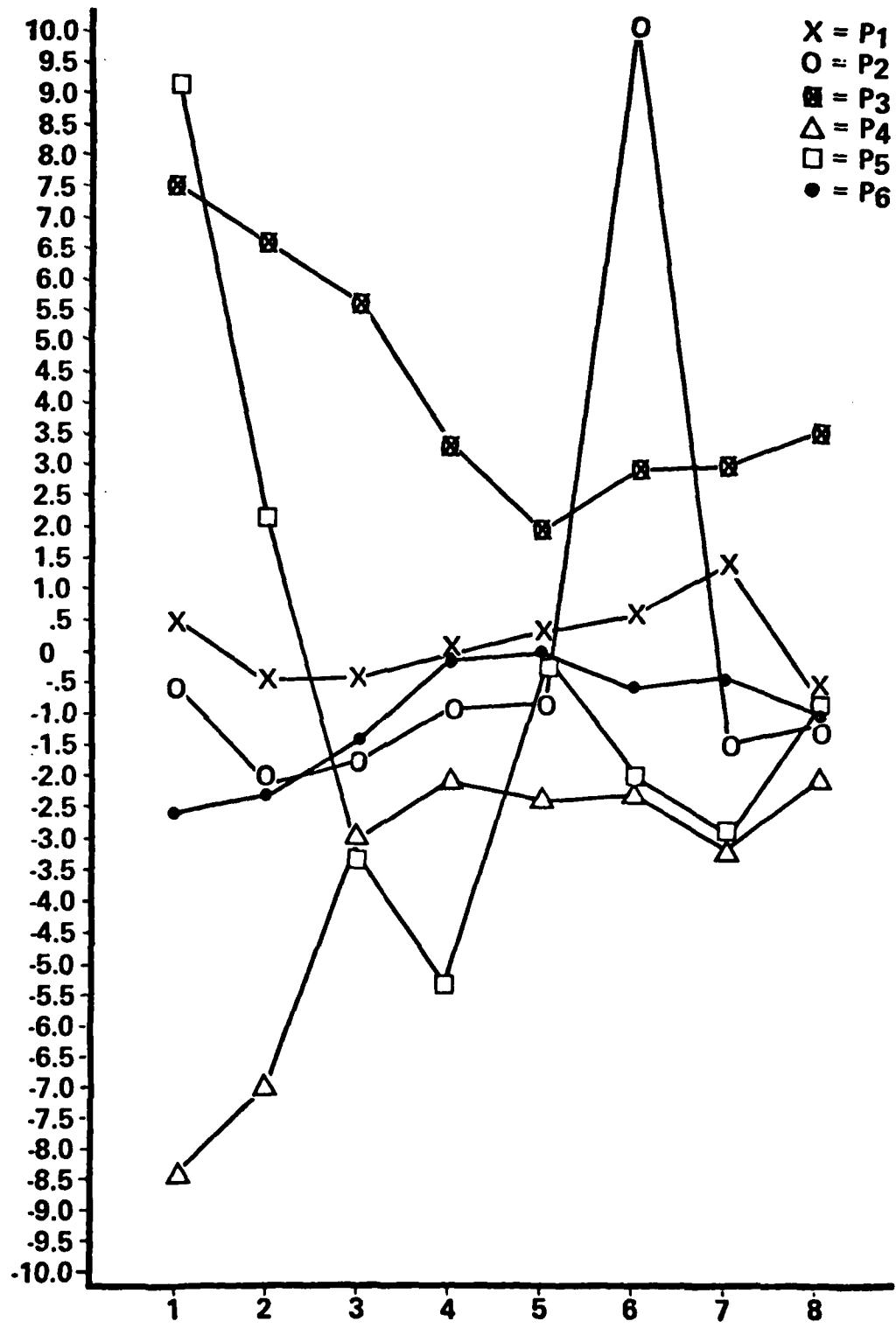


Figure 5. Positions X trials interaction for constant error.

percentage of correct responses. A correct response was defined as the termination of the reproduction of each criterion target within a certain range of that target. The range about each criterion position differed. The correct response range was calculated as the average standard deviation of subjects in the control group at each position. Therefore, there was a different target width for each position. Additionally, the target widths differed for the acquisition and transfer phases of the study. This calculation is similar to the effective target width (W_e) that Schmidt, Zelaznik, and Frank (1978) have proposed as the measure of accuracy in aiming tasks. It was used here because a positioning task is highly similar to an aiming task in that both require an individual to terminate a movement as close to a target as possible.

A 5 X 2 X 6 (strategies X tests X positions) factorial analysis of variance with repeated measures on the last two factors was conducted on the number of correct responses made at each position. There was a significant main effect for tests, $F(1, 45) = 5.10$, $p < .05$, with a greater number of correct responses occurring on the transfer test than on the acquisition test. The means for this effect and all subsequent significant effects appear in Table 4.

Table 4

Mean Scores of Significant Effects for Correct Responses

Tests	Acquisition			Transfer		
	4.56			5.52		
Positions	1	2	3	4	5	6
	5.73	4.97	5.35	3.89	4.96	5.34
Positions						
Tests	1	2	3	4	5	6
Acquisition	4.90	4.38	5.88	2.78	4.64	4.76
Transfer	6.56	5.56	4.82	5.00	5.28	5.92

There was also a significant main effect for positions, $F(5, 225) = 3.76$, $p < .05$. These means are reported in Table 4. Although the follow-up test was not sensitive enough to identify the locus of the significant differences, the serial position curve for this effect is illustrated in Figure 6. As can be seen in the figure, there was both a primacy and recency effect. There was also an elevation of correct response scores at position 3. This was due to the fact that the criterion target was only 25° , and had the largest effective target width from which the correct responses were determined.

Finally, there was a tests X positions interaction, $F(5, 225) = 3.34$, $p < .05$, and this is shown in Figure 7. More correct responses were made on the transfer task at position 4 when compared to the acquisition test at that same position. These means are also provided in Table 4. Additionally, the shape of the acquisition curve resembles that of the position effect curve, while the transfer curve more closely resembles a true serial position curve. This was probably due to the required response at position 3 in the transfer test. Although it was in the short sector, the response was of greater magnitude than 25° .

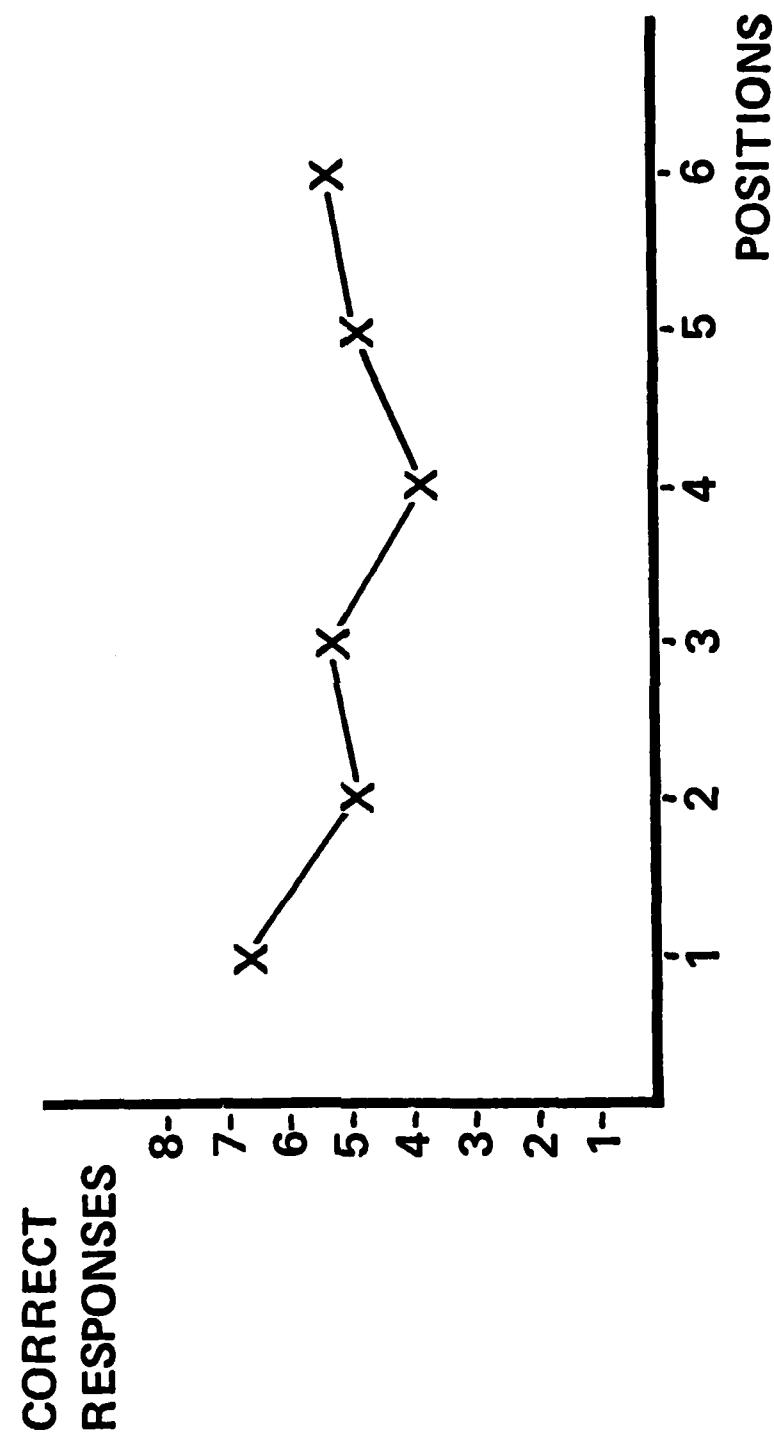


Figure 6. Serial position curve for correct responses.

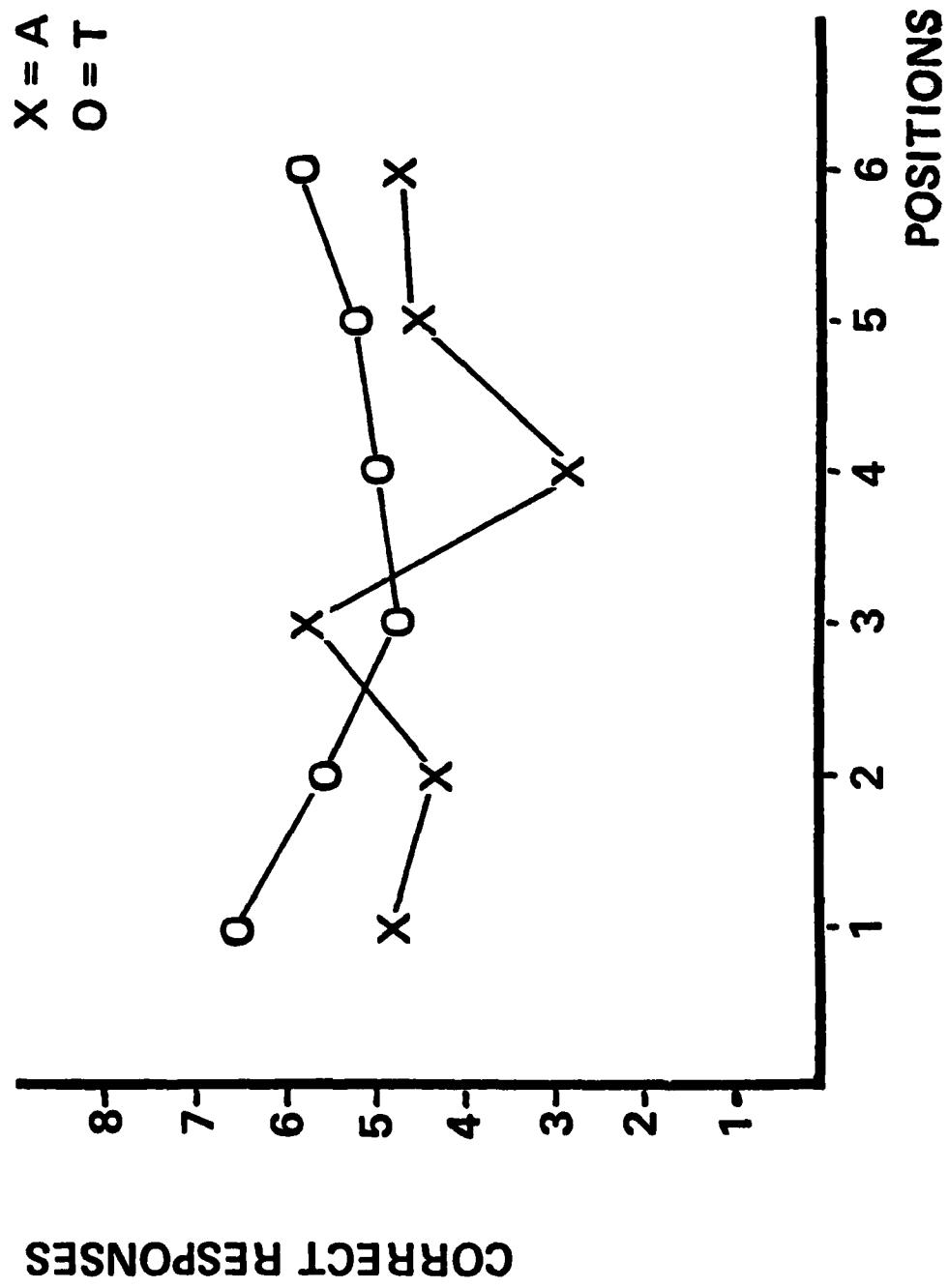


Figure 7. Serial position curve of tests X positions interaction for correct responses.

DISCUSSION

In view of both the absolute and constant error results, the imagery group clearly displayed more accurate performances at 5 of the 6 criterion positions. Such findings would appear to parallel the verbal learning notion that concrete stimulus material is more easily retained than abstract material (Bevan & Steger, 1971; Paivio, 1969). Although subjects were not visually presented with a clock face, it would appear that the strategy instructions (to image the criterion positions as representative of specific time locations) were concrete enough to evoke a clear image for subjects.

"Imagers" were also found to be less variable than the four other groups in their responses. As was pointed out earlier, the VE results were highly similar to the AE results, which emphasizes the notion that problems in response accuracy are linearly affected by inconsistency in response production. Thus, the results clearly support the hypothesis that the imagery group would display superior performance during the acquisition and retention phase of the task. In contrast, however, the results of the present study did not directly support the hypothesis that strategy groups would exhibit superior performance when compared to the control group which used no designated strategy.

The mean scores for both constant error and variable error indicate that the control group displayed greater accuracy and less variability than either the kinesthetic, labeling, or informed choice groups. However, follow-up self-report questionnaires administered after the retention trial and the transfer trials indicated that although control subjects were not given a predesignated strategy, they did in fact self-initiate a strategy. Their superior performance, then, would appear to lend credence to the notion that strategies that are compatible with individual cognitive styles may be more easily adapted by learners (Johnson, 1978; Pask, 1975; Ridsdale, 1978). Similarly, it would appear plausible to assume that control subjects would be more likely to continue using the self-imposed strategy, thus producing more consistent responses.

The inconsistent performance exhibited by the kinesthetic group is somewhat difficult to explain. In light of the role of kinesthetic feedback both during and after movement, one would expect a kinesthetic strategy to improve motor performance. However, it may well be that the kinesthetic sense is an example of a relatively "untapped consciousness." The fact that individuals consistently reflect a visual bias in dealing with the environment would appear to attest to this notion.

Perhaps the potential effectiveness of a kinesthetic strategy can only be evoked after considerable practice across a variety of movement experiences.

The extreme variability in response exhibited by the informed-choice group may be partially due to the fact that only 8 trials were administered. It would seem reasonable to assume that subjects did not have sufficient time to decide which of the strategies was more amenable to their own cognitive style as well as task requirements. Thus, a vascillation between the three strategies presented was manifested in the inconsistency of responses for the informed-choice group.

While it is apparent that, regardless of strategy group, subjects displayed better performances during the transfer task, the differential effect of a particular strategy across acquisition and transfer tasks was not evident.

Perhaps the effectiveness of strategy usage will only be demonstrated with individuals highly practiced in the use of a specific relevant strategy technique (Johnson, 1978). In this sense, individuals can be taught to use a particular strategy across a variety of situations. Once a criterion level of proficiency has been met, different strategy groups may be tested on the same task. By evaluating individuals who are

highly proficient in the use of a particular relevant strategy, the beneficial results of that strategy may be made more apparent.

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APPENDIX A: INSTRUCTIONS TO SUBJECTS
General Instructions for Positioning Task

The curvilinear repositioning task involves moving the handle to a predetermined criterion position. You will be given six different locations which you will be asked to reproduce.

During the two practice trials, I will place a peg in the correct position. You will be asked to grasp the handle in your fingertips and move the lever until you encounter the stop peg. You will then release the handle and I will return it to the start position.

You will receive two practice trials with the pegs in place followed by eight learning trials in which you must reproduce the same six positions, in the correct order, without the aid of the pegs.

After each trial, I will tell you how long or short you were in relation to the correct position. For example, 3° long would mean you went 3° past the target point and 3° short would mean you stopped 3° before the target position. Do you understand?

Imagery Strategy Directions

I am going to inform you of a technique which should improve your performance on this task. It is called imagery. Try to imagine that the criterion points represent the hours and minutes on a clock face. For example, a movement to 90° would be equivalent to 12 o'clock and a movement to a criterion point of 135° would be approximately 7 minutes to twelve. Try to imagine that you are moving to a specific location on the clock each time you move to a criterion position.

During rest periods in between trials, as well as during performance trials, mentally rehearse moving to the criterion positions.

During rest periods between trials, as well as during performance trials, try to use the imagery strategy. Remember, the stop pegs will only be in place during the practice trials. Therefore, it is important that you try to learn the criterion positions during this time.

Labeling Strategy Directions

I am going to inform you of a technique which should improve your performance on this task. It is called labeling. Labeling involves the naming of each criterion position according to degrees. As you move the handle to each criterion position, I will inform you of the specific degrees for that criterion point.

During rest periods in between trials, as well as during performance trials, try to mentally rehearse the degree locations of each criterion position. Remember, the stop pegs will only be in place during practice trials. Therefore, it is important that you try to learn the criterion positions during this time.

Kinesthetic Strategy Directions

I am going to inform you of a technique which should improve your performance on this task. It is called kinesthesia. Kinesthesia involves "the feel of the movement" to each criterion position. As you move the handle, try to feel where your arm and hand are in relation to your body, from the start of the movement until you reach the stop peg.

During rest periods in between trials, as well as during performance trials, try to use the kinesthetic strategy. Remember, the stop pegs will only be in place during practice trials. Therefore, it is important that you try to learn the criterion positions during this time.

Informed Choice Strategy Directions

I am going to inform you of three techniques which may aid your performance on this task. Listen carefully to each description.

(Inform subjects of strategies as provided to each strategy group.)

You have just been informed of three techniques which may help you to learn this task. Feel free to use any one, or any combination of techniques you wish, or disregard all of them. However, a particular technique should aid your performance on this task.

Transfer

You have just been tested on Phase I of the task. You will now learn six new criterion positions. However, you will only receive one practice trial with the stop pegs in place. After each trial, you will again receive feedback information in the form of long or short and the number of degrees.

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